

# NON-DETECTION OF KHZ QPOS IN GX 9+1 AND GX 9+9

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## 1. Introduction

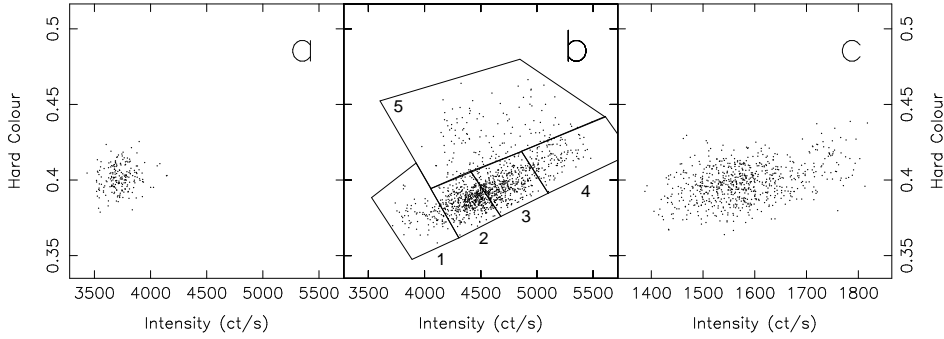
In numerous low-mass X-ray binaries quasi-periodic oscillations (QPOs) between 300 and 1200 Hz have been discovered (the kHz QPOs; see van der Klis 1997 for a recent review on kHz QPOs). Here we present the search for kHz QPOs in the atoll sources GX 9+1 and GX 9+9.

## 2. Observations and analysis

We observed GX 9+1 on 1996 Feb 29, Apr 21, May 29, and 1997 Feb 10 and Mar 9, and GX 9+9 on 1996 Aug 12, Oct 16, and Oct 30 with the RXTE satellite. We obtained a total of 23.3 ksec (GX 9+1) and 15.2 ksec (GX 9+9) of data. The X-ray hardness-intensity diagrams (HIDs) were made using the *Standard 2* data. Due to gain changes the GX 9+1 HID for the 1996 Feb 29 observation can not be directly compared with those of the other observations. The power density spectra were made using the 250 $\mu$ s time resolution data. We calculated rms amplitude upper limits (95% confidence) on QPOs with a FWHM of 150 Hz in the frequency range 100–1500 Hz.

## 3. Results

The HIDs for GX 9+1 and GX 9+9 are shown in Figure 1. According to the HID (Fig. 1a) and the high-frequency noise in the power spectrum GX 9+1 was on the lower banana during the 1996 Feb 29 observation. During the other observations GX 9+1 moved along the banana branch (Fig. 1b). The power spectrum and the HID of GX 9+9 suggest that this source was on the



*Figure 1.* The HIDs of GX 9+1 (*a* and *b*) and GX 9+9 (*c*). The data of 1996 Feb 29 of GX 9+1 (*a*) were taken with a different PCA gain compared to the data of the other observations (*b* and *c*). The intensity is the count rate in the photon energy range 2.0–15.9 keV (*a*) or 2.1–16.0 keV (*b* and *c*); the hard colour is the count rate ratio between 9.7–15.9 keV and 6.5–9.7 keV in *a*, and between 9.7–16.0 keV and 6.4–9.7 keV in *b* and *c*. All points are 16s averages. The count rates are background subtracted, but not dead-time corrected. The regions in *b* have been used to calculate the upper limits.

banana branch during the observations. We find for GX 9+1 upper limits of 1.6% (the 1996 Feb 29 observation; energy range 2–60 keV) and 1.3% (all other observations combined; energy range 2–18.2 keV), and for GX 9+9 an upper limit of 1.8% (all data; energy range 2–18.2 keV). We divided the GX 9+1 banana in Figure 1b into different regions. For each region we calculated the rms upper limit on kHz QPOs. We find rms amplitude upper limits of 3.2%, 1.3%, 1.9%, 2.7%, and 3.4% (energy range 2–18.2 keV), for region 1, 2, 3, 4, and 5, respectively.

#### 4. Discussion

The non-detection of kHz QPOs in GX 9+1 and GX 9+9 is consistent with the predictions of the sonic-point model proposed to explain the kHz QPOs (Miller et al. 1997). It is known from other atoll sources (e.g. 4U 1636–53: Wijnands et al. 1997; 4U 1820-30: Smale et al. 1997) that when they are in the upper banana branch the kHz QPOs are not detected. Thus, it remains possible that when GX 9+1 and GX 9+9 are observed longer on the lower banana, or even in the island state, kHz QPOs are detected in these sources.

#### References

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